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Microbial diversity and biogeochemistry in glacier forefields: assessment of ecological stability in high alpine environments

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Microbial communities inhabiting recently deglaciated, unvegetated, high alpine soils (e.g. glacier forefields) need to be adapted to fluctuating environmental conditions, such as strong daily and seasonal humidity and temperature variations. Soil-related characteristics (e.g. oligotrophy, pH, water holding capacity, nutrient concentration) may in addition determine the presence of locally adapted microbial communities. Currently little is known on the ecological stability (resistance and resilience) of such an environment.

In this project, we aim at understanding ecological stability of microbial communities of alpine glacier forefields through a reciprocal soil transplantation experiment. The study consists in i) determining bacterial phylotypes that may respond to environmental changes and ii) relating biological, chemical and physical data to observed microbial responses.

We selected two different glacier forefields located in the Swiss Alps (approximately at 2500 m.a.s.l.) The Griessen forefield (Canton Obwalden) is characterized by a calcareous bedrock, while the Tiefen forefield (Canton Uri) is of siliceous composition. The sites are well characterized in terms of their geography (e.g. exposure, slope) and climatic fluctuations (Lazzaro *et al.* 2009, Lazzaro *et al.* 2011). At each site, we incubated stainless steel pots with four different soil treatments (autochthonous untreated, autochthonous sterilized, allochthonous untreated and allochthonous sterilized). The setup was repeated in quadruplicate. Soil temperature and soil moisture at 10 cm depth were measured every hour by Decagon EM 50 sensors (Decagon Devices Inc.).

In July (D0), August (D1) and September (D2) 2011, soil aliquots were sampled from the pots for analysis. We plan to further extend the sampling for at least three snow-free seasons (2011-2013). Chemical analysis of the soil encompassed soluble ions, pH and DOC. Bacterial community analysis included microbial biomass (DAPI cell counts), basal activity (microcalorimetry) and community structures (Terminal-Restriction Fragment Length Polymorphism (T-RFLP) profiling of the 16S rRNA gene).

DOC concentrations were within the range of values reported from other glacier forefields ($<$ 0.5 mg [g soil dry wt.]$^{-1}$) and suggested an oligotrophic character of the soils. Nitrate concentrations were apparently not affected by the sterilization but slightly by the transplantation. The nitrate concentration fluctuated strongly from D0 to D3 in a range between approximately 10 – 30 μg NO_3^- [g soil dry wt.]$^{-1}$. Ammonium concentrations were higher (1.5 – 4 μg NH_4^+ [g soil dry wt.]$^{-1}$) in all samples incubating at Griessen. Neither transplantation nor sterilization had an effect on ammonium concentration. T-RFLP analysis showed that the bacterial communities from both soils changed with both the transplantation and time. Moreover, in all sterilized samples, we could observe a gradual increase in operational taxonomic unit (OTU) richness from D0 to D1 and D2. Ongoing analyses, based on the association of T-RFLP profiles and clone libraries, will allow identifying the main phylotypes involved in the community changes and in the colonization processes.

In conclusion, this experimental setup allowed a detailed monitoring of changes of physico-chemical soil properties and of *in situ* microbial responses. Resistance and resilience will be quantified according to community changes observed in the untreated and sterilized soils at different sampling timepoints.

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